



## **Distributing the Costs of Nuclear Core Melts: Japan's Experience after 7 Years**

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# Distributing the Costs of Nuclear Core Melts

## Japan's Experience after 7 Years

Eri Kanamori, and Tomas Kåberger<sup>1</sup>

### Abstract

The costs of managing the consequences of the Fukushima-Daiichi nuclear have been significant already, and the estimated total future costs have increased over time. The immediate payments have been possible by direct payments from the Japanese government. However, most these payments are not acknowledged as government spending. Instead, a complicated system of envisioned re-payments have been created.

Based on the three Special Business Plans published by TEPCO since the nuclear disaster, this evolving perception of the economic consequences and the increasingly complicated repayment schemes are described.

The conclusion of the authors are that the repayment schemes are not compatible with a future efficient, competitive electricity market.

It is suggested that other governments who implicitly or explicitly accepting economic liabilities for nuclear accidents prepare themselves in order to avoid un-necessary indirect cost after future reactors accidents.

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- 1 Eri Kanamori, Ritsumeikan University, Osaka, Japan, [kanamori@ba.ritsumei.ac.jp](mailto:kanamori@ba.ritsumei.ac.jp);  
Tomas Kåberger, Chalmers University of Technology, Göteborg, Sweden, [tomas.kaberg-er@chalmers.se](mailto:tomas.kaberg-er@chalmers.se)

## 1 Background

In this paper, we attempt to describe the way the Government of Japan (GOJ) and Tokyo Electric Power Company (TEPCO) have managed to cope with the successively increasing acknowledged costs of the Fukushima core melts-downs, and following radioactivity leaks in 2011. The evolving scheme of dealing with the cost are found in TEPCO's special business plans.

But first, in this paper, a short description of the consequences of the core melts and of Japan's national energy policy. This, as a background in order to understand the challenges of TEPCO and the design of their recent special business plans:

It was on March 11, 2011 that the three operating TEPCO reactors at Fukushima-Daiichi nuclear power plants proved unable to cope with the effects of an earthquake. The nuclear reactor core melts in Fukushima and consecutive explosions resulted in emission of radioactive substances into the air and water. Despite winds bringing most of the air emissions out into the Pacific, there was also some contamination on land, and over a hundred thousand people were instructed to evacuate their homes, while many in addition relocated at their own initiative, without evacuation orders.

Systematic, comprehensive studies of health effects are not published. Only increased thyroid cancer among children in the affected areas are documented [Tsuda et al. 2015], but sometimes denied to have any relation to the contamination. Thus economic measures of health costs are uncertain and not included in the official cost estimates.

The efforts to control the emissions are still engaging in the order of 5 000 people at Fukushima-Daiichi Nuclear Power Plant. This is many more than the number of people employed when the plant produced electricity.

Removing spent fuel from damaged fuel pools, pumping contaminated water into new-built storage tanks by 2018 containing a million cubic meters, building treatment plants extracting as many radioactive isotopes as possible, and constructing an ice wall around the reactors in order to reduce the amount of water flowing into the most contaminated parts of the plant are some of the short-term efforts. For the longer term, attempts are made to find out where the melted reactor fuel is, and then to develop technologies and strategies for the long term decommissioning of the plant. The work can be followed at the web-site of TEPCO. [TEPCO 2011–2018]

Estimating the total cost from the accident until all the remains of the reactors are brought to a condition where further spreading of radioactivity will be avoided in the very long term is difficult.

The purpose of this paper is not to describe the long-term technical solutions, nor the long term financial solutions. This introduction was intended as a sketchy

background to the financial challenges of managing the consequences. The intention with this paper is to provide a description of how the short-term costs have been managed in Japan since the accident.

Similarly, a brief background of the energy policy follows to understand the way the consequences have been managed:

Japan's energy policy since the 1970s has focused on the development of nuclear power. Despite the absence of domestic uranium reserves, the import of this fuel has been seen as less problematic than dependence on fossil fuel imports. Uranium is easier to store, and a reprocessing ambition, making breeder reactors or production of mixed oxide fuels possible, made the envisioned future import volumes small compared to oil dependence.

Despite strong political backing, the nuclear strategy encountered problems. New reactors were expensive, slowing down the expansion. Even operation of existing reactors have faced problems and the peak in nuclear electricity generation was as early as 1998, with 327 terawatt-hours (TWh) delivered. Still, the last full year before the 2011 Fukushima failure, more than 290 TWh were produced by 54 nuclear reactors in Japan. [BP, 2017]

The Fukushima-Daiichi failure was a serious disaster. Still the "4<sup>th</sup> Strategic Energy Plan" [GOJ, 2014], a cabinet decision made in April 2014, which is the basic and comprehensive Japanese energy policy today, aims at the "Re-establishment of nuclear energy policy" (p.47). The plan says that "Nuclear power is an important base-load power source as a low carbon and quasi-domestic energy source, contributing to stability of energy supply-demand structure, on the major premise of ensuring its' safety" (p.24). It also says that "Even after the TEPCO's Fukushima nuclear accident, use of nuclear energy is expected to expand in the world. The scale of the expansion is particularly remarkable in Asian nations where energy demand is rapidly increasing. Japan, with its experience of the accident, is expected to make contributions in the fields of safety, nuclear non-proliferation and nuclear security as an advanced nuclear nation" (p.50). The latest "5<sup>th</sup> Strategic Energy Plan" [GOJ, 2018] holds the same attitude.

From these statements, it is obvious that Japan's energy policy is still supporting nuclear power. Under this national policy, TEPCO's special business plans have been made and, as we shall describe below, approved by the Government. In the national policy, allocation of the Fukushima costs is not explicitly dealt with. Thus the costs are not visible in the national budget, and not described as a cost of the government. Instead, the matter has been included in TEPCO's special business plans. It is assumed in Japan from provisions of the "Act on Compensation for Nuclear Damage" that only TEPCO is responsible for the accident while the Government is not.

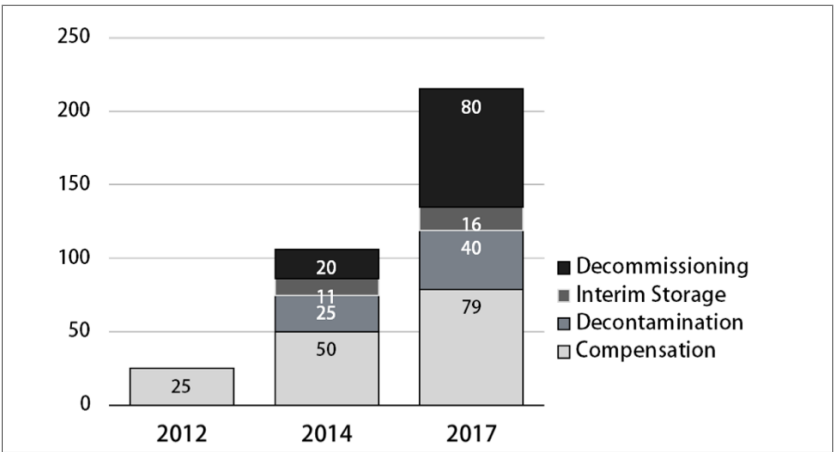
While the government is prescribing how to manage the costs, and in fact providing the necessary funds, the roles of the current government and future tax- and ratepayers are not clearly presented and rarely debated in public.

This paper is an analysis of how the three consecutive special business plans for TEPCO, published after the accident, have evolved; How they present the solution of the challenging task of finding the money necessary to manage the immediate costs of the failure in reactor control after the earthquake.

## 2 TEPCO’s special business plans

In the 2012 special business plan of TEPCO, the acknowledged costs for Fukushima were estimated as 25 billion euros.<sup>2</sup> (Figure 1) This is to pay compensation to victims who were ordered to evacuate from defined areas in the Fukushima prefecture.

In the 2014 plan, the estimated costs became 106 billion euros and it included not only compensation but also some decontamination, interim storage, and decommissioning. And in the 2017 plan, the total costs were assessed as 215 billion euros. The scheme of dealing with these costs will be explained chronologically.



**Fig. 1** The estimated cost of Fukushima accident

2 In this paper, 1 trillion yen is assumed equal to 10 billion euros. In 2018, this is only the right order of magnitude as one Euro is close to 130 JPY.

## 2.1 The 2012 TEPCO Special Business Plan

In the 2012 plan (TEPCO, 2012a), called “Comprehensive Special Business Plan”, Fukushima costs were seen as only compensation and estimated at 25 billion euros.

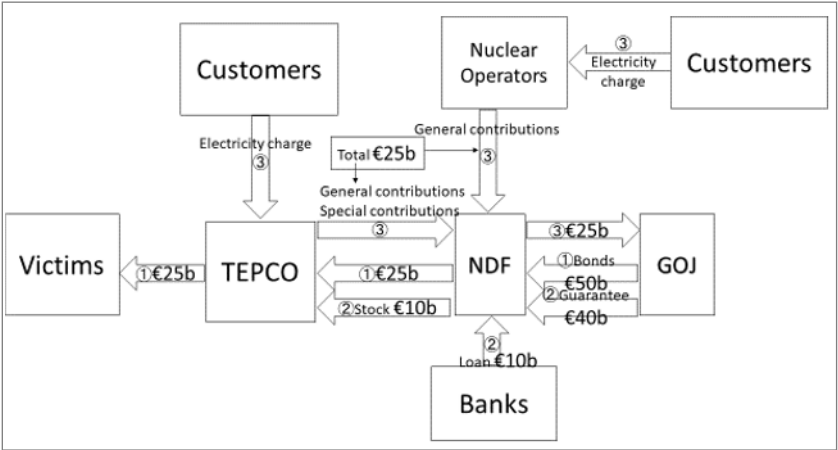
In the financial year ending 31 March 2011, TEPCO recorded a 12 billion euros net loss. This net loss was mainly from asset impairment and efforts to cool and control reactors. Because of the proven loss, TEPCO’s equity was eroded from 21 billion euros in 2009/2010 to 12 billion euros in 2010/2011 (non-consolidated), despite raising a few billions from issuing new shares in October 2010. So, the 25 billion euros of compensation was already bigger than TEPCO’s equity. Thus, this early estimated expense was unaffordable for the company. Under normal economic conditions of limited liability companies in the world, this should have resulted in a bankruptcy where shareholders lost their assets in the company.

However, the government of Japan, instead, decided to rescue the shareholders. The government provided 25 billion euros to TEPCO, for the company to be able to pay compensation, and an additional 10 billion euros in exchange for TEPCO’s new, emitted shares giving the government ownership of 54.69%. This prevented TEPCO from going bankrupt and gave incumbent shareholders an opportunity to stay as owner. At the same time the government avoided making unlimited commitments.

The 10 billion euros payment was mainly to make TEPCO able to pay for its ongoing business activity, such as buying additional fuels and paying interests to banks. Strictly speaking, the government did not do it directly, but through the “Nuclear Damage Liability Facilitation Corporation” (NDF) which they created after Fukushima. As a result, it is the NDF that holds 54.69% of TEPCO’s shares and TEPCO is now controlled by the Government via the NDF.

The scheme of 2012 plan is shown in Figure 2, above. The two government aids are shown as arrows 1 and 2. Arrow 1 shows that the NDF provided 25 billion euros for TEPCO to pay compensation to victims. In order to do this, the Government provided its bonds of 50 billion euros to the NDF. These government bonds were issued for special purpose of supporting compensation and had three features which are different from ordinary bonds: yielding no interests, prohibited to be transferred to a third party, and ready to be redeemed at any time on demand for the purpose. Therefore, when the NDF needed cash in order to assist TEPCO paying compensation, and the NDF demanded it officially to the GOJ, the NDF could acquire cash at any time. From 2012 onwards, the redemption has been repeated monthly. The Government derived the cash from its annual energy budget. It seems that there was already a concern that 25 billion euros might not be sufficient for paying compensation, since the government special purpose bond was up to 50 billion euros already at this stage. At the same time, as arrows 2 show, the NDF invested

10 billion euros in 54.69% of TEPCO’s share. To finance this additional aid, the NDF borrowed the money from banks based on a guarantee from the government.



**Fig. 2** The scheme of the 2012 plan

The money for compensation to victims, it is said, will be paid back to the NDF in a complicated way. A new law was imposed whereby the responsibility to contribute to repayment was shared between all nuclear operators.

In other countries, the liable party would be a matter for courts under existing laws. Here, the Japanese government and diet retroactively distributed the economic liability to all nuclear operators. It may be seen as a retroactive insurance fee that could have been imposed on them beforehand.

As the electricity system, at the time, was operated by regional, vertically integrated, monopolies, costs were easily passed on to electricity customers. While an insurance fee, in a competitive market economy, would have given consumers the opportunity to opt for lower cost sources of electricity, the retroactive charge and the monopoly in the market simply forced customers to pay.

In Figure 2, arrows with the number 3 represent the planned process of repayment. The money is called “contributions.” There are “general contributions” from TEPCO and other nuclear operators and “special contributions” only from TEPCO. In the year of 2016, TEPCO and other operators paid about 1.6 billion euros as general contributions and TEPCO paid an additional 1.1 billion euros. It

was considered that the payment of contributions would last for ten years or so. Of course, this money is expected to continue to come from electricity consumers.

2.2 The 2014 TEPCO Special Business Plan

In 2014, the “New Comprehensive Special Business Plan” was established which disclosed that not only compensation payments would be needed, but also paying for decontamination, interim storage and decommissioning (TEPCO, 2014). The estimated compensation cost was doubled from 25 to 50 billion euros. Decontamination costs of 25 billion euros, interim storage of 11 billion euros and decommissioning of 20 billion euros were now taken into consideration.

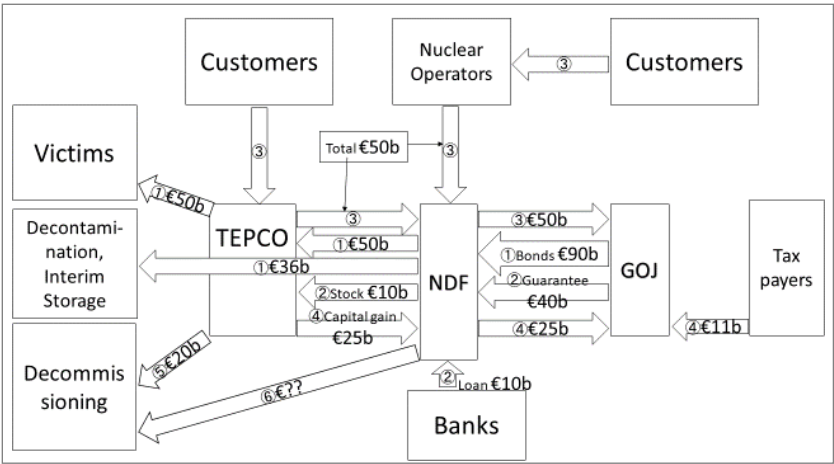


Fig. 3 The scheme of the 2014 plan

Arrows with the number 1, in Figure 3, show how TEPCO was expected to pay 50 billion euros in compensation to victims, the NDF provides the same amount in order for TEPCO to do this. The system for planned repayments stayed the same as in the 2012 plan. The obvious change being that total “contributions” increased to 50 billion euros (arrows numbered with 3).

As for decontamination and interim storage, the two costs are shown together in Figure 3 for practical reasons, and the total amount was 36 billion euros. The NDF



directly makes payments for decontamination and interim storage, not through TEPCO's financial statements. To cover this 36 billion euros, GOJ issued additional special purpose bonds of 40 billion euro. Therefore the total bonds provided to NDF increased from 50 to 90 billion euros (arrow numbered 1 from GOJ to the NDF).

The next question was how to arrange the pay back of this latter amount. As seen before, the contribution from TEPCO and other nuclear operators remained 50 billion euros, which is the same amount of compensation (arrows numbered 3).

Nuclear power companies would not want to, and could not, increase electricity charges further, as a re-regulation process introducing some competition in the electricity sector had started and such obligations would weaken the competitiveness of the companies with nuclear power.

Instead new ways of repayment were invented; capital gain and a special tax. It was planned that 25 billion euros for decontamination is to be covered by imagined future capital gain of TEPCO's share which the NDF holds, termed capital gain. The 11 billion euros of interim storage costs shall come from the Government energy budget (arrows 4).

As for the last category of Fukushima cost, 20 billion euros of decommissioning of Fukushima-Daiichi nuclear power plant is planned to be financed by TEPCO's management effort through cost reduction and sales of assets (arrow 5). This is a very ambitious task for TEPCO management, considering the plans to increase competition in the Japanese markets. And all this, while electricity consumption is falling, and decentralised solar electricity is increasing its' market share. To be able to collect the benefits of efficiency as profit, the achieved efficiency improvements must not only cover this cost compared to today operations, the improvements must be so much better than improvements among competitors, in order to generate the profit necessary to cover the costs.

In addition, there was one more important feature in the decommissioning scheme of 2014 plan. GOJ began to support research and development (R&D) of decommissioning methods applicable to the crippled reactors in Fukushima (arrow 6). It is unknown how much the NDF will pay for R&D of Fukushima decommissioning. The law was changed and NDF before abbreviation was, as a consequence, renamed as "Nuclear Damage Compensation and Decommissioning Facilitation Corporation", and the function of decommissioning facilitation was added to NDF. (GOJ, 2014, p.48)

2.3 The 2017 TEPCO Special Business Plan

The 2017 plan revealed that Fukushima estimated cost increased to 215 billion euros (TEPCO, 2017). Compensation, decontamination, interim storage and decommissioning were given as 79 billion, 40 billion, 16 billion, and 80 billion euros respectively. The scheme to cover costs became even more complex.

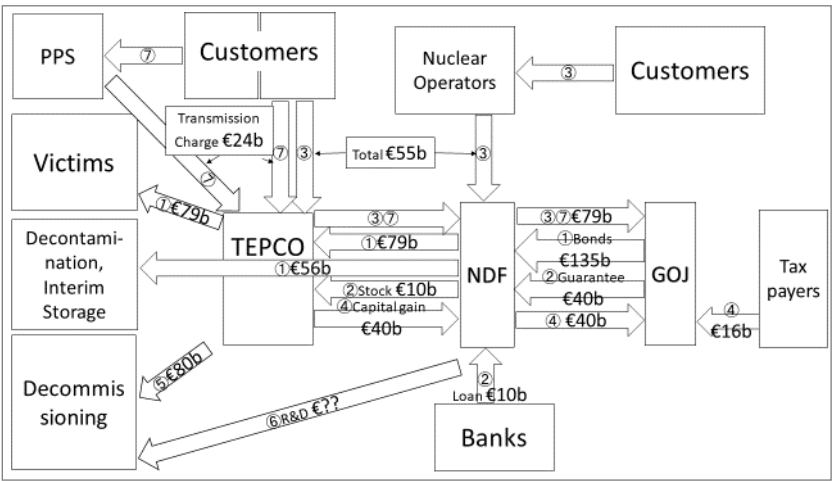


Fig. 4 The scheme of the 2017 plan

Firstly, compensation of 79 billion euros is provided by the NDF as in the 2014 plan (arrows 1). But changes were made in the repayment process. The contribution did not go up to 79 billion euros. Instead, a part of the compensation was to be repaid through a new channel: from a transmission charge (arrows 7). This, in practice, means that the economic liability for the nuclear accident consequences will be paid also by customers who are buying no nuclear electricity at all. The interpretation that the contribution was a retroactive insurance payment by all nuclear operators is now no longer possible. Instead all electricity consumers are paying.

TEPCO's consumers split into two groups after April 2016 when some competition was introduced in the Japanese electricity retail market. Some consumers remained TEPCO's customers and continued to pay electricity charges to TEPCO. Others switched retailers and are now paying electricity charges to other suppliers. TEPCO could not collect money from the latter consumers anymore.

So, the new way of collecting money from these consumers by using transmission charge was invented. Now, TEPCO's customers pay additional charges to TEPCO. And PPS who use transmission services of TEPCO also pay an extra charge. This charge is set to yield the 24 billion euros needed to pay back to the NDF and GOJ together with the contributions. Accordingly, the contribution becomes 55 billion euros in total. In other words, 55 billion euros (arrows 3) and 24 billion euros (arrows 7), both charged on consumers, will be used to pay back to the money of compensation.

Next is decontamination and interim storage. In the 2017 plan, the total cost of the two was 56 billion euros. But this amount cannot be financed by the 90 billion which the NDF provided to TEPCO in the 2014 plan, because from that sum, they already pay compensation of 79 billion euros. So, in the 2017 plan, the Government decided to provide additional bonds of 45 billion euros, resulting in total amount of 135 billion euros (arrows 1). The repayment scheme of the two costs is the same as 2014 plan: Decontamination of 40 billion euros is to be paid back from capital gain, while interim storage of 16 billion is from Government's energy budget which means from other tax income or further national borrowing.

It might be necessary to note here that the anticipated capital gain of 40 billion euros is not a credible expectation in the absence of any privilege given to TEPCO in the future competitive electricity market. The NDF holds 54.69% of TEPCO's share, after paying about 10 billion euros. In order to get 40 billion euros capital gain, the share price must increase to 50 billion euros. 50 billion euro for half of TEPCO means around 100 billion euro for 100% of the company. Therefore, TEPCO's market value in the future must become more than 100 billion euros. This is hard to imagine if customers in Japan are to enjoy electricity at prices that can make industrial customers competitive, and give households a decent standard. The reality among large peers in Europe is that Edf, with roughly the double installed generation capacity to TEPCO had a market value of some 20 billion euros at the end of 2016.

Finally, decommissioning costs, that are estimated to be 80 billion euros in the 2017 plan, will be financed by TEPCO's management efforts. There is no change about this scheme. Then, what is TEPCO's management efforts in 2017 plan? In Fuel/Thermal Power business, TEPCO plans to reduce maintenance cost by 30% (TEPCO, 2017, p.28). This, again, is very ambitious. It is so, not only considering the Fukushima events but in relation to the track record of TEPCO's management before 2011. Pursuing cost cuts must not affect the safety of its business and the efforts to avoid more accidents. This is particularly relevant in the nuclear business, where they are planning to restart of Kashiwazaki-Kariwa nuclear power station

(TEPCO, 2017, p.37), a plant that has experienced severe difficulties in operation even before the Fukushima failure.

In Transmission and Distribution business, the plan says that TEPCO will raise 1.2 billion euro/year on average through rationalization (TEPCO, 2017, p.30). Rationalization, again means cost reductions. If this is possible, one may ask why it has not been done already.

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### 3 Discussion

The full costs of the Fukushima nuclear reactor core melts are not yet possible to quantify. Still, the costs already identified and acknowledged by the Japanese government are so large they are beyond the paying capacity of any reactor owner in the world, and clearly beyond the paying capacity of TEPCO.

In a stepwise process, the unavoidable costs of the Fukushima disaster have been identified and distributed by the Japanese government. Worth noting, is that in this process the government has protected TEPCO owners from bankruptcy. This could be seen as introducing a moral hazard: While the report by National Diet of Japan Accident Investigation Committee has concluded TEPCO is responsible for the consequences by neglecting warning of earthquakes and tsunamis, pointing out that “Risk of the arrival of a tsunami was known by both Nuclear and Industrial Safety Agency and TEPCO in 2006, but TEPCO neglected this risk and no measures were taken” (1.2 of PART 1), TEPCO has been protected from the economic consequences by the government. The government has placed the economic cost and responsibility on the customers and tax payers, but not on the owners of the plant. The moral hazard appear as other industries may come to expect similar protection and abstain from taking costly precautions when learning about risks in their activities.

Now, the Japanese people are compelled to pay for most of the costs. Still, the schemes set up for this purpose. The complexity of the plans, and the lack of transparency in reporting the use of money provided by the Governments or regulated contributions collected from ratepayers, makes public debate and democratic control difficult or impossible.

Some part of the plan deserves public scrutiny as the current government plans may appear unrealistic, thus creating problems and deficits for future Governments. It is for example hard to believe that a 40 billion euros capital gain will be secured by TEPCO in the competitive electricity markets that exists in most countries and that is now also said to be developed in Japan. Similarly, it is hard to believe that

significant profits can be made by cost reducing management efforts if the markets are really competitive. These plans seem to rely on assumptions about electric power companies being able to in some way tax consumers rather than supplying in a competitive market.

Thus one may see these plans as only postponing the understanding of what the government is going to have to provide through increasing taxes on the Japanese people in an already weak government budget situation.

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## 4 Conclusions

Seven years after the nuclear core melts the experience shows a lack of readiness, and absence of any plan for how to manage the economic consequences of an accident of this magnitude.

Still, the improvised solutions, have for the seven years both kept the government's borrowing capacity intact, and allowed TEPCO to avoid going bankrupt.

We dare predict that the 2017 TEPCO Special Business Plan will be impossible to fulfil. Further improvised and complicated solutions may follow. However, it is increasingly unlikely that the current idea of nuclear power companies in different ways paying will be compatible with the global development of low cost renewable electricity generation technology and competitive electricity markets. Instead the development appears likely to make it impossible to generate profits by nuclear or other large scale thermal power plants. Even without the Fukushima related liabilities, Japan's electric power companies would have economic challenges.

A less complex solution, worth investigating further, would be that the government directly takes over all the nuclear liabilities from the power companies and have the power companies paying by transferring the transmission network to a government controlled national transmission system operator. That solution would support, rather than conflict with, the ongoing electricity market reform, and transition to low cost electricity. It would, in one move, unbundle transmission from generation and create the conditions necessary for an efficient electricity market reducing costs for Japan's future electricity supply.

The experience is also relevant when considering restarting reactors, re-introducing the risks of further reactor accidents in Japan. Had Japan seen winds bringing more contamination over land – or even worse, in the direction of Tokyo – the financial consequences may not have been manageable by the government or the Japanese society by itself.

This observation leads to the need to find market based solutions that will distribute costs globally. Here the idea of a compulsory insurance via catastrophe bonds appears as an option deserving further consideration [Radetzki & Radetzki 2000, Kåberger 2018].

The experience of Japan may prove valuable for consideration also in other nuclear countries. Though many of these are operating under different legislation and international conventions regarding liability for reactor accidents, the real magnitude of the economic consequences are often not understood by people within the democratic decision making processes in Europe or North America.

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